BELLCOMM, INC.

SUBJECT: Influence of Space Vehicle Returns to the VAB on Lunar Launch Opportunities - Case 330

DATE: April 3, 1967

FROM: D. M. Duty
C. H. Eley III

## ABSTRACT

The return of an Apollo/Saturn V space vehicle (SV) to the VAB during pad operations for a lunar mission will influence the operational ability to meet lunar launch opportunities. VAB return requirements are defined by the SV/pad configuration at the point during prelaunch operations when a return to the VAB is initiated. These requirements and the associated VAB return times are examined for five pad configurations presently being used for planning at KSC. The influence of a SV return to the VAB on monthly lunar launch opportunities is discussed in terms of these configurations.

It is concluded that:

a. If a hurricane recycle to the VAB occurs after L-24 days (calendar), the SV will not be able to meet the beginning of the first lunar launch opportunity.

b. If a hurricane recycle to the VAB occurs after L-17 days (calendar), it will not be possible to launch the SV during the first lunar launch opportunity.

c. If an orderly return to the VAB (for repair) is made after SV hypergolics loading is completed (T-8 days), it is uncertain whether the SV can be returned to the pad and prelaunch operations completed before the end of the second lunar launch opportunity.

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MEMORANDUM FOR FILE

## 1. INTRODUCTION

The return of an Apollo/Saturn V space vehicle (SV) to the VAB during pad prelaunch operations for a lunar mission will influence the operational ability to meet lunar launch opportunities. Contingencies which would require returning the space vehicle to the VAB generally fall into two categories:

a. Weather conditions (i.e. hurricanes).

b. Repair/Replacement.

VAB return requirements are defined by the SV/pad configuration at the point during prelaunch operations when a return to the VAB is initiated. Preliminary planning at KSC has defined five such pad configurations. These configurations have associated with them the required operations and return times to effect the VAB transfer. This memorandum examines the prelaunch operations in terms of these configurations for returns to the VAB under (a) and (b) above, and discusses their effect on the ability of the SV to meet a lunar launch opportunity following a VAB return.

## 2. ORDERLY RETURN TO THE VAB

### a. General

LC-39 pad operations are presently planned to begin about 39 calendar days prior to the beginning of the launch opportunity for a lunar mission.* This operations plan utilizes a 5-day workweek leaving approximately 8 weekend days for contingency operations.

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*Based on the Preliminary KSC Manned Lunar Test Flow Chart dated March 14, 1967.

Since a requirement to return the SV to the VAB could occur at any time during pad operations, the configuration of the complex and condition of the SV are the primary factors in determining the time needed to accomplish the transfer. For purposes of mission planning, five SV/pad configurations have been selected by KSC.* These configurations, defined at specific points during prelaunch operations, are as follows:

| Configuration | Stage of Pad Operations |
|---|---|
| #1 | After SV/GSE/Facility mate to the pad but prior to the arrival of MSS. |
| #2 | After SV/GSE/Facility mate with pad and MSS but prior to hypergolic and SC cryogenic loading. |
| #3 | After hypergolic and RP-1 loading with MSS in place at the pad. |
| #4 | After hypergolic, RP-1 and SC cryogenic loading, SC fuel cell activated, ordnance items connected except destruct system and MSS in place at the pad. |
| #5 | After a launch scrub-hypergolics, RP-1 and cryogenics loaded, SC fuel cells activated, ordnance items connected, including destruct system, MSS removed, and swing arms and damper strut retracted. |

The nominal orderly return time required for each configuration is listed in Table 1, including a tabulation of the major operations involved. The times include a 3-hour allowance for securing the SV in the VAB.

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*Preliminary KSC Transfer Operations Charts, Pad-to-VAB, dated March 8, 1967.

TABLE 1

| Configuration | Operations for an Orderly VAB Return | Time to Return to VAB |
|---|---|---|
| #1 | o Move CT to pad<br>o Secure LV stages and GSE<br>o Secure Service Arms<br>o Secure Facilities<br>o Secure ESE<br>o Secure holddown arms and tail service mast<br>o Disconnect from Pad<br>o Move to VAB | 20 hours |
| #2 | Configuration #1 Operations Plus<br>o Secure SC, LV, GSE, and facilities from MSS<br>o Move MSS | 28 hours |
| #3 | Configuration #2 Operations Plus<br>o Drain and purge SC and S-IVB hypergolic systems<br>o Drain RP-1 | 5 days + 2 hrs + 28 hrs = 6 days 6 hrs |
| #4 | Configuration #3 Operations Plus<br>o Install platforms and safe ordnance<br>o Remove flight batteries and boost protective cover<br>o GSE hookup and cryogenics removal<br>o Fuel cell cool down and SC ordnance removal | 8 days + 2 hrs + 28 hrs = 9 days 6 hrs |
| #5 | Configuration #4 Operations Plus<br>o LUT connections, safing, LV propellant drain and purge<br>o MSS to pad and connections | 9 days + 2 hrs + 28 hrs = 10 days 6 hrs |

b. SV/Pad Configuration Impact on VAB Return Times

It can be seen in Table 1 that the time required to return the space vehicle to the VAB for each configuration progressively increases as pad operations proceed toward launch day. (Figure 1 shows the configuration status during the various stages of pad operations.) The increase in return time produced by this progression is discussed in the following:

Configuration #1 - The build-up of configuration #1 at the launch pad occurs over a three-day period (Figure 1). The dividing line between configurations #1 and #2 is considered to be defined by the point in the schedule where LV power is turned on and hardware checks begin.

The VAB return time for configuration #1 will vary depending on the phase reached during this portion of the countdown. Preliminary plans indicate a minimum return time of 14 hours and a maximum return time of 20 hours are required. This variation is caused primarily by the location of the Crawler Transporter, the time required to transfer it to the pad, and the amount of SV securing required which again is dependent on the build-up in configuration #1.

Configuration #2 - This configuration is reached when the MSS is transferred and integrated with the SV and pad. The effect on a VAB return is to increase the time required over that for configuration #1 by 8 hours. The additional 8 hours is required to detach the MSS and remove it from the launch pad.

The above operational return time is dependent on the availability of one or two Crawler Transporters. Operations using a single CT adds three hours to this return time.

Configuration #3 - The build-up to configuration #3 from configuration #2 is basically complete when hypergolic propellants and RP-1 are fully loaded (T-8 days). These operations extend over a four-day period. As seen in Table 1, when this configuration is reached, the time required for an orderly VAB return significantly increases. VAB return time will be increased by 5 days if hypergolics are fully loaded. These 5 days are presently required to drain the SC and S-IVB hypergolic propellants and purge the subsystem with $GN_2$.

The major portion of this time is required to purge the subsystems of hypergolics to the safety level presently required in the VAB. Sufficient experience in this particular operation has not yet been attained; therefore, the 5-day number is not firm.

If the SV/pad is not fully in configuration #3 (hypergolics not completely loaded), the additional five days might be reduced; but at present such times have not been determined. Also, LV detanking of RP-1 fuel adds two hours to the return time.

Configuration #4 - This configuration is reached with the loading of the SC cryogenics, fuel cell activation and ordnance items connected. Preparations for reaching this point are started during the latter portion of configuration #3. The impact on VAB return time will again be dependent on the point in time that a return is initiated. Assuming a complete configuration #4, the VAB return time is increased by three days over that required for configuration #3. This additional time is required to detank SC cryogenics, secure SC systems and remove SV ordnance.

The 3 days allotted for these operations are broken down as follows:

1. SLA, CSM, and GSE preparations (8 hrs).
2. Unloading of SC LOX, $LH_2$ and $GH_e$ (8 hrs).
3. Secure LV (8 hrs).
4. Fuel cell cooldown (39 hrs).
5. SC ordnance removal (16 hrs).

A portion of these operations may be done in parallel, but items 4 and 5 are presently scheduled as serial operations and account for more than 2 of the 3 days.

Configuration #5 - This is actually the launch configuration with LV propellants fully loaded--such as would be the situation during the CDDT and launch countdown. The VAB return time in this case will be increased by one day over that required for configuration #4. This time is required to move the MSS to the pad, detank LV cryogenics, and purge the stages for operations associated with a configuration #4 return to the VAB.

## 3. HURRICANE RECYCLE TO THE VAB

### a. General

Hurricanes exhibit a nearly uniform wind profile from the ground level up to several hundred feet and are characterized by wind speeds of 64 knots or greater--usually greater. Historical data shows that hurricane close approaches to KSC (within 300 n.m.) occur primarily in the months of June through October with August, September and October the most predominant. Since hurricanes need only make a close approach to generate damaging winds and rain, the probability of having to recycle the SV to the VAB is greatest during a full quarter of each year.

The current wind level limitation for moving the MSS with the CT is 35 knots at the 60-foot level, and for the SV/ML 50 knots at the 195-foot level. In relation to this, the hurricane warning conditions at KSC are:

| Condition | Hurricane winds 50 mph predicted to occur within (hours) |
|---|---|
| I | 12 |
| II | 24 |
| III | 48 |
| IV | 72 |

### b. Hurricane Recycle Prior to SV Hypergolics Loading

As shown in Table 1, the time to return the SV to the VAB is 20 hours for configuration #1 and 28 hours for configuration #2. The hurricane recycle of AS-500F to the VAB last June was accomplished in 12 hours. At the time, this vehicle was roughly in a configuration #1 status. However, since AS-500F carried a dummy spacecraft, the return time for a complete Apollo/Saturn V would probably conform more closely

to the current KSC schedule. Depending on local conditions, weather predictions, etc., it appears that a move to the VAB should be started as soon as hurricane condition III is set.

c. Hurricane Recycle After SV Hypergolics Loading

As shown in Figure 1, all SV hypergolic propellants are loaded by T-8 days. Thereafter, the pad configuration is always #3 or greater. It is easily seen from Table 1 that orderly return times required for configurations #3, #4 or #5 greatly exceed the current hurricane warning conditions at KSC. To alleviate this constraint, the KSC safety office has stated that if sufficient time does not exist to detank and purge the SV hypergolic subsystems before an approaching hurricane imperils the SV, the SV/ML can be moved back to the VAB with hypergolics on board. This is an obvious choice rather than risk severe damage and/or loss of the SV. The time required to return the SV to the VAB without detanking hypergolics would correspond more closely to the maximum time required for a configuration #2 schedule. The time, however, to complete an emergency transfer would increase as the pad area reached configuration #4 and #5. Configuration #5 involves the greatest emergency return time since both SC and LV cryogenics would have to be detanked and purged, and SV ordnance removed in addition to the other requirements (about 50 hours). However, it is doubtful that KSC would commit the vehicle to a configuration #5 status (LV cryogenics loaded) with an existing hurricane condition of III or greater.

d. Hurricane Recycle for two Space Vehicles

The possibility exists that schedule and hardware conflicts could result in two space vehicles being on-pad at the same time. An alternate contingency situation here is that of a concurrent hurricane recycle being required. In such a situation, the approach of a hurricane would probably find each space vehicle in a different configuration. There are, however, no apparent constraints in effecting a double return to the VAB and this is only mentioned here as a further consideration.

4. ABILITY TO MEET THE LAUNCH OPPORTUNITY

a. After Hurricane Recycle to the VAB

The chances of a hurricane recycle occurring are, at best, limited. However, it is certainly probable that LC-39 will experience another hurricane recycle (as in the case of AS-500F). If this involves a lunar mission vehicle, what will be the effect on the launch opportunity?

A VAB return during prelaunch operations will impact the lunar launch opportunity to a degree dependent on the SV/pad configuration and the amount of pad operations required to bring the SV status back to the point when the VAB return was necessary. An examination of the turnaround times would indicate that to meet that month's launch opportunity, the VAB return must occur during the early part of pad operations.

Figure 2 shows the ability to meet the original launch opportunity following a hurricane recycle to the VAB. There are two basic assumptions in this figure.

(1) The VAB stay time is dependent on the weather conditions. Assuming that there are no VAB operations other than securing the SV, a stay time of two days is used.

(2) The SV can be launched in 22 days (calendar) after initiation of movement back to the pad.

The VAB-to-pad return time will depend on the amount of pre-move preparations accomplished during the two-day period above. Assuming the majority of preparations are made during the latter part of this time, approximately 22 hours will be required to transfer and mate the SV to the pad.

The critical point in the prelaunch operations appears to be prior to FRT preparation and after SC systems verification (see Figure 1). The SV is in configuration #2 at this time and requires 4.2 days for a VAB turnaround. If 4 days are allowed at the pad for integration and verification of the configuration, 8.2 days would have been lost from the schedule. This assumes that after the 4 days (on pad), preparations for the FRT could begin.

Part of the 8.2 days could be regained by going to a 7-day workweek. The weekend time remaining at this point would be 6 days. Utilizing this time puts the schedule 2.2 days into the 8-day launch opportunity. Depending on the launch windows selected during these 8 days, it would still be possible to launch that month. The turnaround time, as defined by the above phases, is therefore variable, being a function of SV/pad configuration, weather conditions and VAB operations. Thus, it can be seen that after the SV has been on pad for more than two weeks, a hurricane recycle could cause the launch date to begin slipping to a later time in the launch opportunity. A hurricane recycle <u>after</u> the first three weeks on pad will cause the initial launch opportunity to be missed completely. Note that in order to effect this turnaround, the SV/pad configuration can never be greater than configuration #2.

b. Orderly Recycle to the VAB

An orderly recycle to the VAB would normally occur when some repair/replacement in the SV is required which cannot be performed at the pad. This type of contingency becomes significant after loading SV hypergolic propellants (configuration #3) since the lifetime of the hypergolic subsystems is limited once they have been wetted.

Figure 3 shows the ability of the SV to meet the second monthly launch opportunity with an orderly recycle to the VAB after hypergolics loading. If prelaunch operations after SV return to the pad can be completed in 22 days, a maximum of 10 days is available for time in the VAB, depending on the point at which the return is initiated (before the first launch opportunity). The stay time available in the VAB (to make the second opportunity) is progressively reduced for returns from configurations #4 and #5.

The time which might actually be required in the VAB depends on the type and amount of repair involved. Since it must be something which could not be accomplished at the pad, it is safe to assume that this would be an operation of major proportions (such as demate, or F-1 engine change) requiring a significant amount of time to complete. Hence, given a 90-day lifetime for the SC hypergolic subsystems*, the probable schedule impact for a return to the VAB (for repair) is that at least one and possibly two of the three available launch opportunities will be missed.

5. CONCLUSIONS

It is concluded that:

a. If a hurricane recycle to the VAB occurs after approximately L-24 days (calendar), the SV will not be able to meet the beginning of the first lunar launch opportunity**.

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*This is contingent upon a successful requalification program by MSC. Current subsystem lifetimes are 30 days for the CSM and 44 days for the LM.

**These times will probably change since they are based on assumptions and preliminary KSC plans. However, it is felt they would not change greatly--particularly for a decrease.

b. If a hurricane recycle to the VAB occurs after approximately L-17 days (calendar), it will not be possible to launch the SV during the first lunar launch opportunity**.

c. If an orderly return to the VAB (for repair) is made after SV hypergolics loading is completed (T-8 days), it is uncertain whether the SV can be returned to the pad and prelaunch operations completed before the end of the second lunar launch opportunity.

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Attachment
Figures 1-3

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M. Savage - NASA/MLT
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W. T. Clearman - KSC/DG
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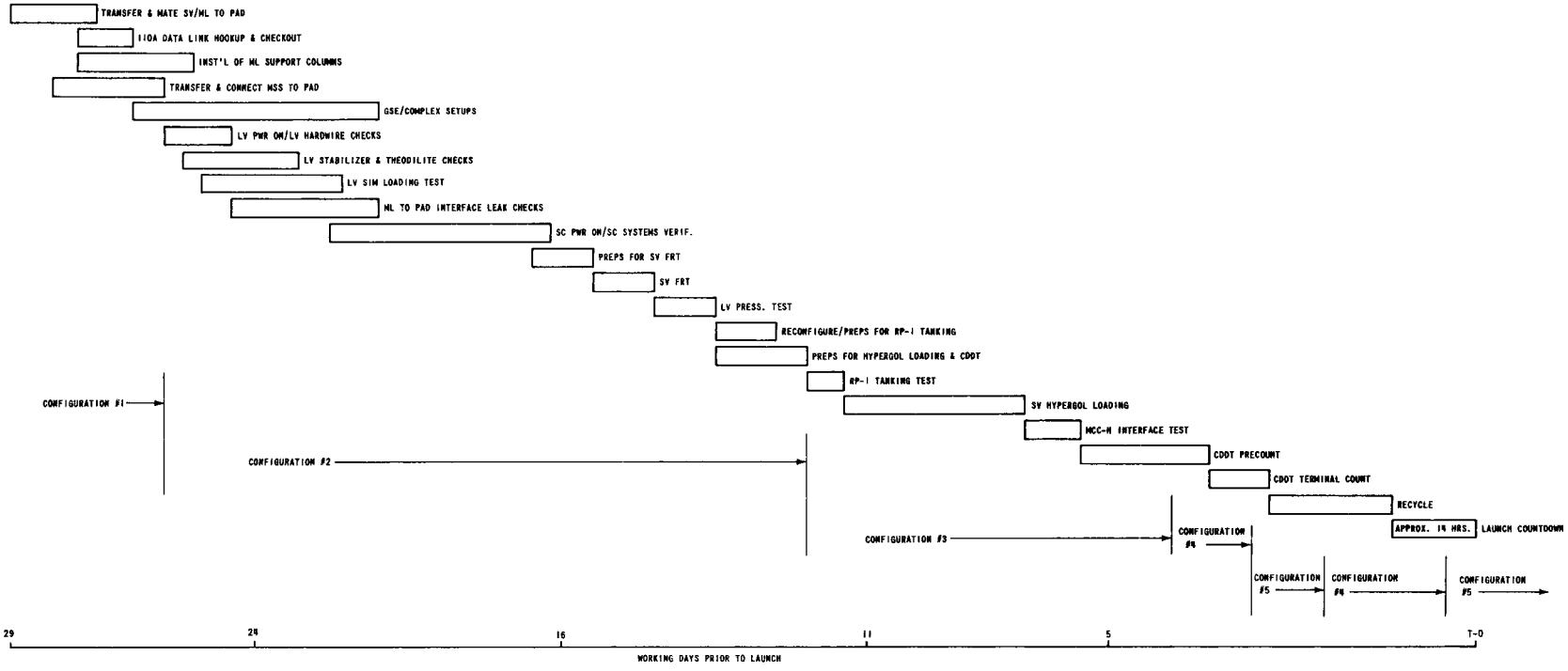
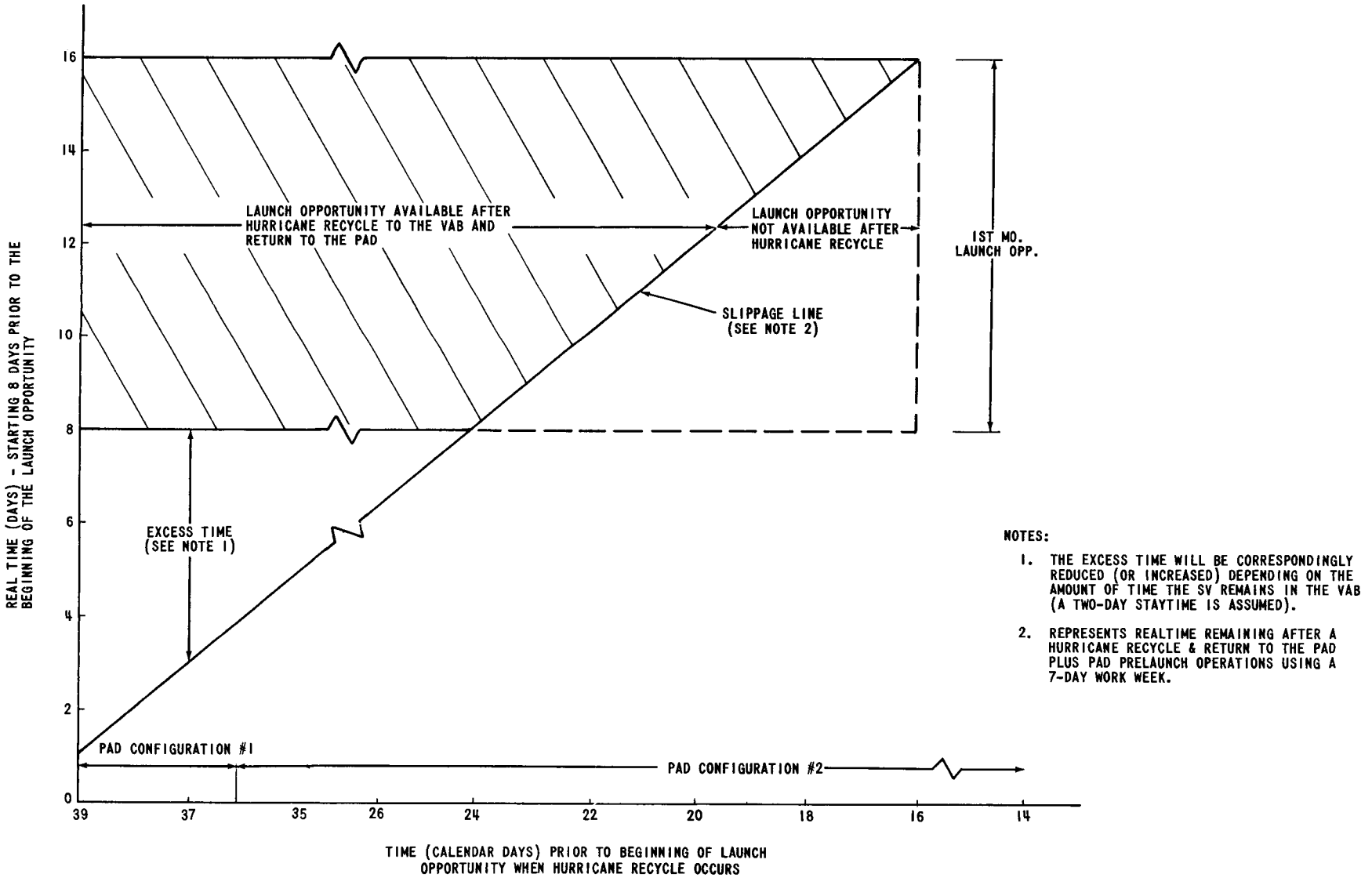



FIGURE 1 - LUNAR MISSION PAD OPERATIONS FLOW




NOTES:

1. THE EXCESS TIME WILL BE CORRESPONDINGLY REDUCED (OR INCREASED) DEPENDING ON THE AMOUNT OF TIME THE SV REMAINS IN THE VAB (A TWO-DAY STAYTIME IS ASSUMED).
2. REPRESENTS REALTIME REMAINING AFTER A HURRICANE RECYCLE & RETURN TO THE PAD PLUS PAD PRELAUNCH OPERATIONS USING A 7-DAY WORK WEEK.

FIGURE 2 - ABILITY TO MEET PART OF A LAUNCH OPPORTUNITY FOLLOWING A HURRICANE RECYCLE

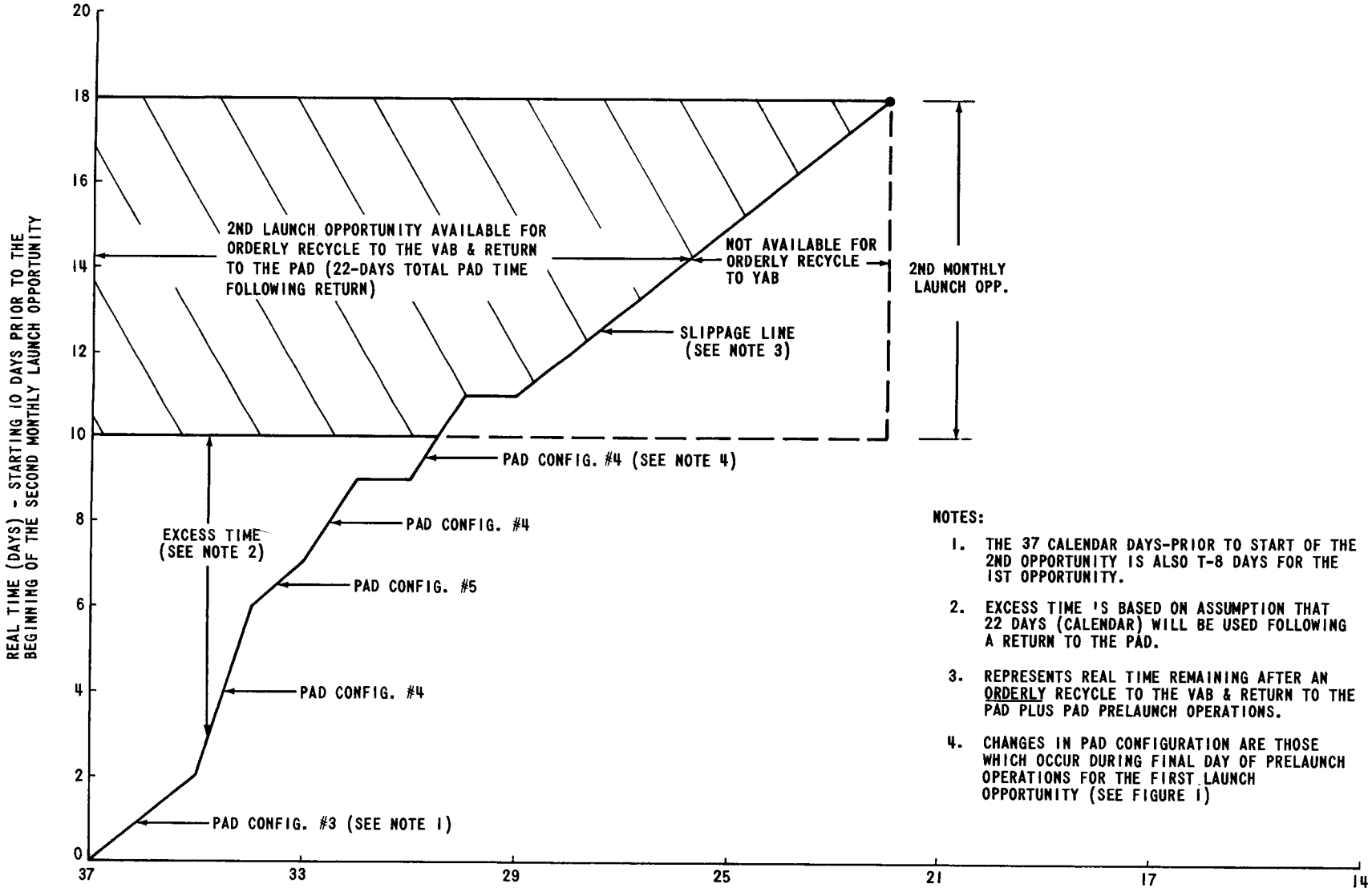



FIGURE 3 - ABILITY TO MEET THE SECOND LUNAR LAUNCH OPPORTUNITY AFTER AN ORDERLY RECYCLE TO THE VAB